From 0.80 to 0.90 seconds, the ball is still at its original position. At 0.95 seconds the ball hits the ground, bounces back up at 1.00 seconds and returns to the ground at 1.05 seconds.

To calculate the distance it bounced up I looked at the position column. The ball starts 45.6cm from the motion sensor. It then hits the ground that is 60.2cm from the motion sensor. This means the ball dropped 14.6 cm (60.2-45.6). The ball then bounces back up where it is now 47.0 cm away from the motion sensor. The ball rebounded 13.2cm (60.2-47.0) after it hit the

	. ground
tion	0.000

 Time (s)
 Position (m)

 16
 0.80
 0.456

 17
 0.85
 0.455

 18
 0.90
 0.454

 19
 0.95
 0.602

 20
 1.00
 0.470

 21
 1.05
 0.623

 22
 1.10
 0.449

 23
 1.15
 0.669

 24
 1.20
 0.562

 25
 1.25
 0.626

 27
 1.35
 0.626

 27
 1.40
 0.626

The tables below show the data collected from my experiment. The processed data for this lab is the coefficient of restitution. I have included the coefficient of restitution in the raw data table so you can easily see how when the rebound height decreases, the coefficient of restitution decreases. I expected to see this relationship because a lower coefficient of restitution means the collision is more inelastic, and a lower rebound height means that more energy is lost during the collision.

EX Repeated trials, a reasonable range of data, and uncertainties support the reliability of the data.

A The tables are appropriate and clear. They provide the information the student needs for the

graphs.

Size 1 Soccer Ball

Stone	Pressure (+/- 0.5lbs.)				
Height rebounded	10.0	8.0	6.0	4.0	2.0
Trial 1(+/- 0.1cm)	110.3	87.4	43.0	20.4	6.2
Trial 2(+/- 0.1cm)	107.1	85.6	42.3	23.3	4.4
Trial 3(+/- 0.1cm)	108.6	87.8	44.7	24.8	6.0
Average (+/- 0.01cm)	108.7	86.9	43.3	22.8	5.5
Coefficient of restitution (+/- 3.8x10 ⁻³)	0.9	0.8	0.5	0.4	0.2

Dirt	Pressure (+/- 0.5lbs.)				
Height rebounded	10.0	8.0	6.0	4.0	2.0
Trial 1(+/- 0.1cm)	0.3	2.8	6.2	9.3	0.0
Trial 2(+/- 0.1cm)	0.0	0.0	4.7	11.5	0.0
Trial 3(+/- 0.1cm)	0.0	0.0	5.5	13.1	0.0
Average (+/- 0.01cm)	0.1	0.9	5.5	11.3	0.0
Coefficient of restitution (+/- 0.0)	0.0	0.1	0.2	0.3	0.0

Grass			Pressure (+/- 0.5lbs.)		
Height rebounded	10.0	8.0	6.0	4.0	2.0
Trial 1(+/- 0.1cm)	87.3	68.6	33.9	21.2	4.0
Trial 2(+/- 0.1cm)	79.1	71.1	32.3	18.4	7.6
Trial 3(+/- 0.1cm)	82.8	74.7	29.0	18.9	6.1
Average (+/- 0.01cm)	83.1	71.5	31.7	19.5	5.9
Coefficient of restitution (+/-3.2x10 ⁻³)	0.7	0.7	0.5	0.4	0.2

4





Size 3 Soccer Ball

Stone	Pressure (+/- 0.5lbs.)				
Height rebounded	10.0	8.0	6.0	4.0	2.0
Trial 1(+/- 0.1cm)	92.0	72.7	34.3	13.8	2.1
Trial 2(+/- 0.1cm)	92.8	72.1	41.0	25.2	1.8
Trial 3(+/- 0.1cm)	92.1	73.0	33.8	17.1	3.2
Average (+/- 0.01cm)	92.3	72.6	36.4	18.7	2.4
Coefficient of Restitution (+/-3.6x10 ⁻³)	0.8	0.7	0.5	0.4	0.1

Dirt	Pressure (+/- 0.5lbs.)				
Height rebounded	10.0	8.0	6.0	4.0	2.0
Trial 1(+/- 0.1cm)	0.0	3.0	4.0	9.0	0.0
Trial 2(+/- 0.1cm)	0.0	2.0	6.0	8.0	3.0
Trial 3(+/- 0.1cm)	0.0	0.0	5.0	11.0	0.0
Average (+/- 0.01cm)	0.0	1.7	5.0	9.3	1.0
Coefficient of Restitution (+/- 0.0)	0.0	0.1	0.2	0.2	0.1

		Pressure (+/- 0.5lbs.)		
10.0	8.0	6.0	4.0	2.0
72.0	71.0	25.0	11.0	4.0
76.0	67.0	22.0	13.0	6.0
74.0	68.0	1.0	8.0	4.0
74.0	68.7	16.0	10.7	4.7
0.7	0.7	0.3	0.3	0.2
	10.0 72.0 76.0 74.0 74.0 0.7	10.0 8.0 72.0 71.0 76.0 67.0 74.0 68.0 74.0 68.7 0.7 0.7	Pressure (+/- 0.5lbs.) 10.0 8.0 6.0 72.0 71.0 25.0 76.0 67.0 22.0 74.0 68.0 1.0 74.0 68.7 16.0 0.7 0.7 0.3	Pressure (+/- 0.5lbs.) 10.0 8.0 6.0 4.0 72.0 71.0 25.0 11.0 76.0 67.0 22.0 13.0 74.0 68.0 1.0 8.0 74.0 68.7 16.0 10.7 0.7 0.7 0.3 0.3

A Here and in the following graphs there is too much information on a single graph to allow a clear appreciation. A better focus would have helped the student. The scale and units overlap making the graph somewhat confused. In fact, there are serious errors in the representation of the data. On graph 1, the data for size 1 soccer ball (from page 4) shows the coefficient of restitution going from zero up to 0.3 and then back to zero for "dirt," yet on the graph it is labelled "grass," with a red square. Same for graphs 2 and 3 on pages 6 and 7.

5



Graph 2: Coefficient of Restitution for size 3 soccer ball. The three different symbols represent different surfaces. ****Vertical error bars are too small to be visible****

Size 5 Soccer Ball					
Stone			Pressure (+/- 0.5lbs.)		
Height rebounded	12.0	9.0	7.0	4.0	2.0
Trial 1(+/- 0.1cm)	87.8	73.1	41.3	17.2	6.1
Trial 2(+/- 0.1cm)	92.9	67.0	39.6	21.5	5.8
Trial 3(+/- 0.1cm)	89.3	74.7	43.2	18.2	4.2
Average (+/- 0.01cm)	90.0	71.6	41.4	19.0	5.4
Coefficient of Restitution (+/- 3.5x10 ⁻³)	0.8	0.7	0.5	0.4	0.2
Dirt			Pressure (+/- 0.5lbs.)		
Height rebounded	12.0	9.0	7.0	4.0	2.0
Trial 1(+/- 0.1cm)	0.0	3.0	6.0	9.0	0.0
Trial 2(+/- 0.1cm)	0.0	0.0	4.0	11.0	0.0

Trial 3(+/- 0.1cm)	0.0	0.0	5.0	13.0	0.0
Average (+/- 0.01cm)	0.0	1.0	5.0	11.0	0.0
Coefficient of Restitution (+/- 0.0)	0.0	0.1	0.2	0.3	0.0
Grass			Pressure (+/- 0.5lbs.)		
Height rebounded	12.0	9.0	7.0	4.0	2.0

Height rebounded	12.0	9.0	7.0	4.0	2.0
Trial 1(+/- 0.1cm)	79.0	62.4	38.1	16.0	5.7
Trial 2(+/- 0.1cm)	80.8	63.1	37.8	15.4	4.3
Trial 3(+/- 0.1cm)	76.8	67.9	40.3	13.2	6.0
Average (+/- 0.01cm)	78.9	64.5	38.7	14.9	5.3
Coefficient of Restitution (+/- 3.2x10 ⁻³)	0.7	0.7	0.5	0.3	0.2

C The student's representation of the data is far from perfect. Once again, the student mixes up grass and dirt representations on graphs 2 and 3.



Graph 3: Coefficient of Restitution for size 5 soccer ball. The three different symbols represent different surfaces. *** *Vertical error bars are too small to be visible* ***



Graph 4: The above graph shows the rebound height of the three balls when they are dropped on grass.



Graph 5: This graph shows the rebound height of the three balls when they are dropped on stone.

7



